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# THE INFLUENCE OF COGNITIVE TRAINING ON BALANCE IN OLDER ADULTS

Dissertação submetida à Escola Superior de Tecnologia a Saúde do Porto para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Terapia Ocupacional, realizada sob a orientação científica de Professora Doutora Maria Cristina Damas Argel de Melo, da Área Técnico-Científica de Fisioterapia e de Professor Doutor Tiago Filipe Mota Coelho, da Área Técnico-Científica de Terapia Ocupacional.

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# The Influence of Cognitive Training on Dynamic Balance in Older Adults

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**Abstract**

**Background:** Aging causes brain changes on the central nervous system, specifically in the gray and white matter. The changes caused in the white matter affect executive function and balance. **Aim(s):** To analyze the influence of a specific cognitive training on static balance in older adults. **Methods:** This is a controlled trial. The sample of this study consisted of a group of 22 participants aged 63-80 years, of both genders and physically active. The evaluations were twice/week for 12 weeks. Data regarding participants' physical activity, cognitive performance, mobility and lower limb strength was collected with standardized measures. Balance was assessed with an EMED NOVEL performed pre and post intervention with three months apart. The intervention group performed a cognitive exercise program, which focused on executive function, (1h/session, pressure platform. Center of Pressure (COP) displacement length and velocity variables (global, anterior-posterior, medio-lateral directions) were analysed. These evaluations were performed pre and post intervention with 3 months apart. The Mann-Whitney test was used to see differences between groups (independent samples) and the Wilcoxon to see differences between moments (related samples). However, this type of analysis, divided into several tests, increases the error type 1. **Results:** Statistically significant differences ($p<0,05$) between assessments (pre and post intervention) were only found for the control group regarding lower limb strength and COP maximal velocity (global, anterior-posterior directions). Indeed, the control group's lower limb strength and balance declined, while there were no statistically significant differences between moments for the intervention group. **Conclusion:** The balance of the participants of the control group declined between assessments, whereas there were no differences in the balance of the participants of the intervention group. This may have been consequences from gains in executive function as a consequence of the cognitive training. However, the results of the present study are limited, and further research is required.

**Key words:** older adults; static balance; double support; COP displacement; executive function.

**Resumo**

**Introdução:** O envelhecimento provoca alterações cerebrais ao nível do sistema nervoso central, mais especificamente na substância cinzenta e branca. As alterações provocadas na substância branca afetam as funções executivas e equilíbrio. **Objetivo (s):** Analisar a influência de um treino cognitivo específico no equilíbrio estático em adultos mais velhos. **Métodos:** Este é um estudo controlado. A amostra deste estudo consistiu num grupo de 22 participantes, com idades compreendidas entre 63-80 anos, de ambos os sexos e fisicamente ativos. Foi realizada uma avaliação pré e pós intervenção com três meses de diferença. O grupo de intervenção realizou um programa de exercícios cognitivos, focando-se na função executiva (1h/sessão, 2x/semana durante 12 semanas). Relativamente aos dados dos participantes da atividade física, desempenho cognitivo, equilíbrio e funcionalidade estes foram recolhidos através de testes standardizados. O equilíbrio foi avaliado com a plataforma de pressões EMED NOVEL Foram analisadas as variáveis do comprimento do deslocamento do centro de pressão (COP) (global, ântero-posterior e medio-lateral) e da velocidade máxima (global, ântero-posterior e medio-lateral). Estas avaliações foram realizadas pré e pós intervenção com três meses de diferença. O teste de Mann-Whitney foi utilizado para verificar as diferenças entre grupos (amostras independentes) e o Wilcoxon para diferenças entre momentos (amostras emparelhadas). **Resultados:** As diferenças estatisticamente significativas ($p<0,05$) entre avaliações (pré e pós intervenção) apenas foram encontradas para o grupo de controlo relativamente à força dos membros inferiores e à velocidade máxima do COP (global, ântero-posterior e medio-lateral), pois a força dos membros inferiores e o equilíbrio do grupo de controlo diminuíram, enquanto que no grupo de intervenção não existiram diferenças significativas entre momentos no grupo de intervenção. **Conclusão:** O equilíbrio dos participantes do grupo de controlo diminuiu entre as avaliações pré e pós intervenção, além disso não existiram diferenças no equilíbrio dos participantes do grupo de intervenção. Tal facto pode ter sido consequência dos ganhos de função executivas como consequência do treino cognitivo. Contudo, os resultados do presente estudo são limitados, e por isso requer mais investigação.

**Palavras-chave:** adultos mais velhos; equilíbrio estático; double support; deslocamento do COP; funções executivas.

# Index

# I. Introduction

Aging is an inevitable phenomenon in the path of all human beings. According to the Statistics Portugal, the elderly population aged than 65 years increased between the censuses of 2001 and 2011 and will increase at least to 32% by 2050 (INE, 2013).

According to this fact, there is a consensus that efforts should be made so that older adults can enjoy life in the best way possible. Spirduso, Francis and MacRae (2005) stated that an active life can improve mental, physical and social functions of older adult, so the establishment of certain strategies is necessary, to minimize the negative effects of aging, and to help the maintenance of functional capacity, autonomy and cognitive function (Argimon, Bicca, Timm, & Vivan, 2006; Tribess & Virtuoso, 2005).

It is known that aging is a very complex process, (Tribess and Virtuoso, 2005) leading to a height loss, decreased muscle strength and bone mass, changes in the cardiovascular system, (Spirduso et al., 2005) musculoskeletal, neuromotor and sensory systems, which increase the risk of balance loss and falling (Sakari-Rantala, Era, Rantanen, & Heikkinen, 1998). The term balance is defined as the ability to maintain the position of the body on its support base, fixed or movable with minimum fluctuations (Silveira, Prenuchi, Simões, Caetano, & Golbi, 2006).

In fact, ageing also affects the central nervous system, with structural and functional changes in cortical and spinal and peripheral level (Papegaaij, Taube, Baudry, Otten, & Hortobágyi, 2014). Cortical and spinal mechanisms play an important role in postural control, balance included (Woollacott, Bonnet, & Yabe, 1984).

Verdu, Ceballos, Vilches, and Navarro (2000) affirmed that 8-18% reduction in the density of myelinated and unmyelinated fibres, more specific in peripheral nervous system, are related to age, compromising nerve conduction velocity. Furthermore (Bartzokis et al., 2001; Ge et al., 2002; Salat et al., 2004) indicated that the structural changes also have repercussion in a cortical level, with a notable reduction in volume of gray and white matter and white matter integrity. The reduction in gray matter volume happens in the areas of association: prefrontal and inferior parietal cortex, sensory and motor areas (Salat et al., 2004).

Therefore, all changes to the central nervous system, due to aging, affects cognition and balance (Shumway-Cook & Hoollacott, 2007), more specifically the white matter, which at a microscopic level, has an effectiveness related loss of the work of neural networks, which will affect executive functions and balance (Anderson, Jacobs, & Anderson, 2008). So brain ageing changes will affect both, level of cognitive ability, particularly executive function, and postural control, particularly in balance (Moraes, Moraes, & Lima, 2010).

van Iersel, Kessels, Bloem, Verbeek, and Rikkert (2008) verified that the crucial cognitive factor in gait and balance would be the executive functioning. These previous studies clearly show that older people with poor executive functioning walk slower, have increased stride variability, fall more often, and have poorer performance on complex mobility tasks (Hausdorff, Yogev, Springer, Simon , & Giladi , 2005; Springer et al., 2006).

The concept executive function (EF) is defined as a set of cognitive skills that are necessary to plan, monitor, and execute a sequence of goal-directed complex actions (Lezark, Howieson, Loring, Hannay, & Fischer, 2004). EF can be subdivided into different areas: cognitive flexibility (ability to change strategies or rephrase plans when conditions change); working memory (recent information storage and manipulation necessary to understanding, learning and reasoning); selective attention (to ignore irrelevant stimuli and focus only one); problems solving (to find a solution for a particular obstacle) and planning and sequencing (to determine what steps are needed to reach a goal) (Simões et al., 2013).

In fact, cognitive functions, namely executive function and attention are very important to the performance of the gait (Al-Yahya et al., 2011; Fasano, Plotnik, Bove, & Berardelli, 2012; Hausdorff et al., 2005; Herman, Mirelman, Giladi, Schweiger, & Hausdorff, 2010; Huxhold, Li, Schmiedek, & Lindenber, 2006; Mirelman, Herman, Brozgol, & Dorfman, 2012; Rosano et al., 2012). Cognitive domain, specifically EF are suffering a decrease with age, and it has a greater contribution to the motor tasks, gait and balance (Woollacott & Shumway-Cook, 2002; Schaefer & Schumacher, 2011). Thus can say there is a connection between the falls and cognitive decline (Chen, Peronto, & Edwards, 2012; Tinneti, 2003; Springer, et al. 2006).

There are some benefits of physical and cognitive training in dynamic balance (Salazar-González et al., 2014) as with age the gait relies more on attention, orientation and memory, and therefore the implementation of interventions involving physical and cognitive are of utmost importance to improve the skills during the gait in older adults

(Hausdorff et al., 2005; Lord & Rochester, 2007; Holtzer, Verghese, Xue, & Lipton, 2006; Sheridan, Solomont, Kowall, & Hausdorff, 2003; Yogev-Seligmann, Hausdorff, & Giladi, 2008). Moreover, some authors argue that divided attention an executive function component, is associated with gait in older adults (de Bruin & Schmidt, 2010; Hajjar et al., 2009; Herman et al., 2010; Holtzer, 2006, 2007; Inzitari et al., 2007).

As it can be seen above, there is an extensive range of evidence that cognitive training positively influences the dynamic balance, but what happens in static balance? According to Muir-Hunter et al. (2014), the links between cognitive function, balance and risk of falls among the elderly are not yet fully studied. For this reason, the research question of this article is "What is the influence of a cognitive training program on static balance in older adults?"

This study aims to analyze the influence of a specific cognitive training program with specific domains of executive function (cognitive flexibility, selective attention, problem solving, planning and sequencing and planning and working memory) in the static balance of older adults.

# II. Methods

## 2.1 Study Design

A randomized controlled trial study was performed in a group of community-dwelling older adults.

## 2.2 Sample

The sample was composed by 20 participants who were recruited randomly from the 34 overall target population that took part in the exercise program "Live the Mo(ve)ment" from Pasteleira's Towers Residents Association, in Foz do Douro, in Porto, Portugal. This program aims to reduce the fall risk factors and comprises strength, flexibility, balance training.

The participants were submitted to a questionnaire where inclusion and exclusion criteria were included. Inclusion criteria were defined as: to have age ≥ 60 years, to be physically active, through the Timed Up and Go Test (TUG) and Five Times Sit to Stand Test. And the exclusion criteria were defined as: who had moderate to severe cognitive impairment (Montreal Cognitive Assessment (MoCA) scores of ≤ to 16), cardiac disease or severe neurological disease and vertiginous syndrome, inferior member amputated, were medically advised against performing moderate physical exercise (e.g.: severe heart pathology, moderate/severe osteoporosis, severe pulmonary disease), were diagnosed with a motor function compromising neurological disease (e.g.: Cerebrovascular accident, Parkinson 's disease, Vertiginous Syndrome), taking vestibular system or motor function (e.g. equilibrium) diminishing drugs.

With the application of the inclusion and exclusion criteria, the sample was struck up to 20 participants, which were then distributed randomly to the intervention group (IG) and control group (CG). Randomization was performed using an Excel function. IG integrated an extra cognitive training sessions besides the sessions of the Live the Mo(ve)ment program and CG continue to attain it. IG lost two participants due to low attendance to the program (Figure I).

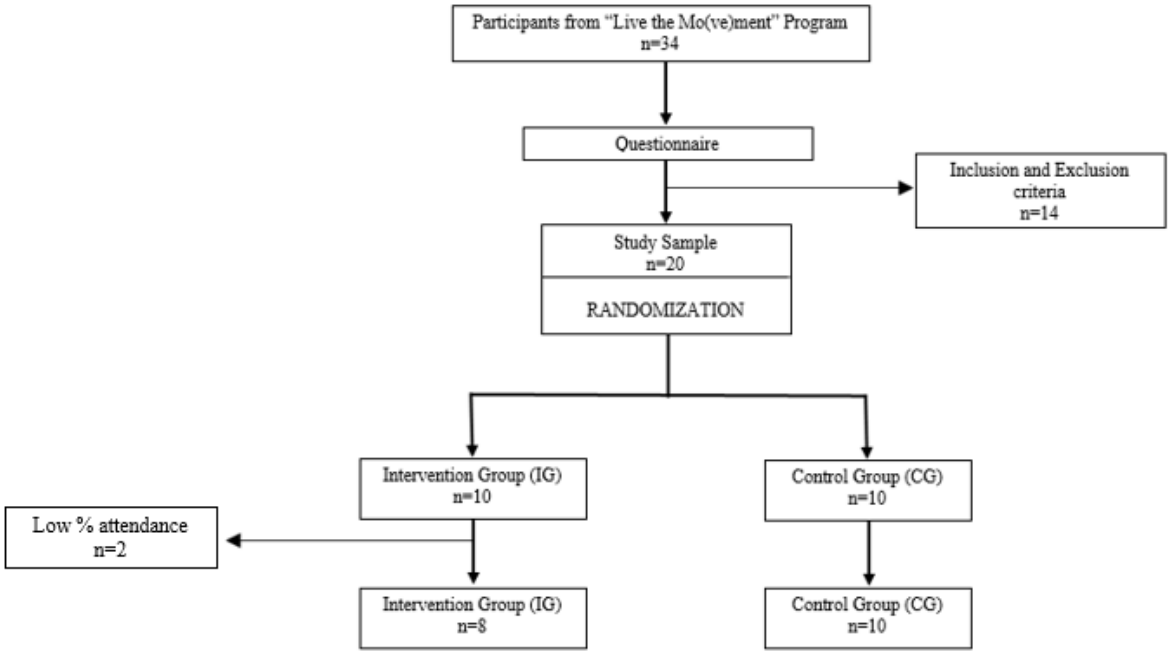


**Figure I**- Sample selection diagram

### 2.3 Instruments

#### i. Sociodemographic characterization assessment protocol

For the characterization of the sample and the application of the inclusion and exclusion criteria, an assessment protocol was delivered, which presented 3 sections: socio-demographic data (gender, age, marital status and academic qualifications), clinical data (Annex 2).

This assessment protocol was only used for pre-intervention evaluation.

#### ii. Scale and metric-tape

A non-elastic COMED® (France) ribbon-metric (0,1cm precision to a 2 meter maximum measure) and a Tanita branded scale, model BC-545 InnerScan™ (USA) (maximum capacity of 150 Kg and 0,1Kg precision) were used, for the collection of anthropometric measurements [height and weight, respectively for subsequent calculation of body mass index (BMI)].

#### iii. Montreal Cognitive Assessment (MoCA) version 7.3

MoCA has been implemented, not only to control the cognitive dysfunction, as well as assess executive function; visuospatial ability; working concentration, attention and

memory; language; special guidance and temporal Simões et al. (2008). According to the same author was held cultural adaptation and validation version of the criteria in the Portuguese MoCA.

There is evidence to prove the good psychometric properties of this test in particular required his temporal stability test-retest r=0,92 [p <.001; 35,0 (± 17,6) days] (Rahman & Gaafary, 2009).

The values have been adapted for this study to moderate-severe (scores≤16), (Rossetti, Lacritz, & Cullum, 2011) (Annex 4).

### iv. Stroop Test

The Stroop Test was used to analyze selective attention capacity and cognitive flexibility. Its' similar format to *Stroop Neuropsychological Screening Test* (Trenerry, Crosson, Deboe, & Leber, 1995), has been validated for the Portuguese population by (Castro, Cunha, & Martins , 2000) (Figure II).

The test consists of two parts, one was a training part and second was a test "Color Nomination" and "Color Reading". The maximum time for executing each part is 120 seconds. The total time to perform the test was registered as well as the total of words and the number of correct and incorrect words (Annex 5).

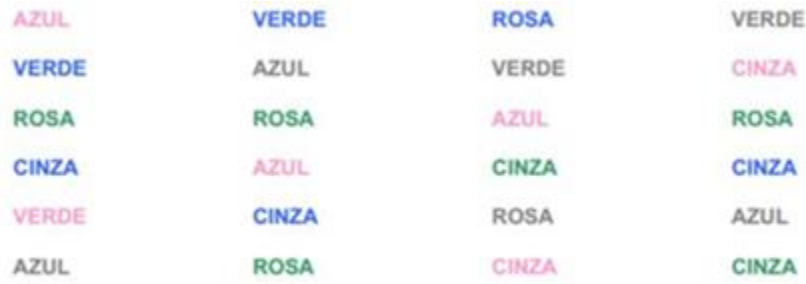


**Figure II**- Example of Stroop Test (Portuguese version used)

### v. Trail Making Test (TMT)

TMT was used to evaluate selective attention, cognitive flexibility, planning and sequencing (Lezar, 1995; Mitrushina, Boone, & D'Elia, 1999; Spreen & Strauss, 1998; Tombaugh, 2003).

The TMT is composed by two parts, A and B. Both test's parts are composed by 25 circles, distributed in a paper sheet (Figure III). This test had a typical maximum time of 300 seconds (Bowie & Harvey, 2006) (Annex 6)

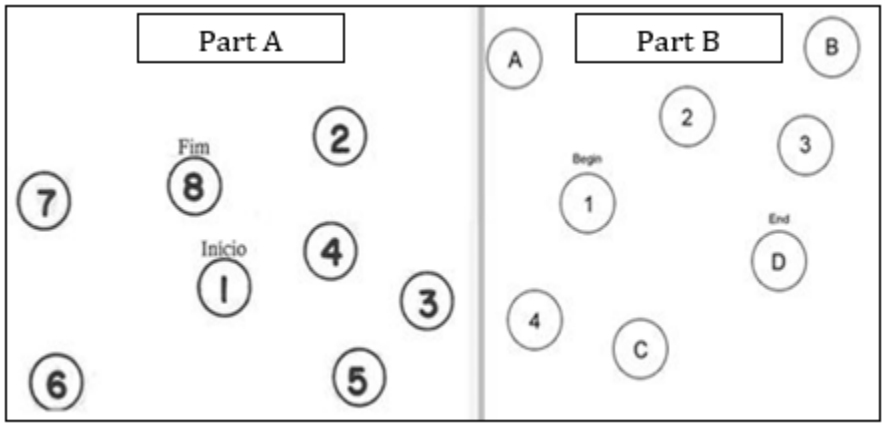


**Figure III**– Example of the Trail Making Test: Part A and Part B

### vi. Verbal Digital Test (VDT)

The VDT is an oral presentation sequence numbers that quantifies working memory, planning and sequencing, and cognitive flexibility and is divided in 2 parts (Forward Digit Span and Backward Digit Span) (Figueiredo & Nascimento, 2007; Simões et al., 2013), (Figure IV).

The maximum score in the direct direction is 16 points and in the reverse order of 14 which leads to a total score (sum of direct and reverse order points) of 30 points.

The digits were read at a rate of one per second and there were two attempts at each level; the test ended when the volunteer failed two sequences at the same level (Banhato & Nascimento, 2007) (Annex 7).

| | | Dígitos em Sentido Direto | | | | Dígitos em Sentido Inverso | | |
|---|---|---|---|---|---|---|---|---|
| | Ens.1 | 1 - 7 | | | Ens.1 | 2 - 4 | | |
| | Ens.2 | 6 - 3 | | | Ens.2 | 5 - 7 | | |
| Item 2 | Ens.1 | 5 - 8 - 2 | | Item 2 | Ens.1 | 6 - 2 - 9 | | |
| | Ens.2 | 6 - 9 - 4 | | | Ens.2 | 4 - 1 - 5 | | |
| Item 3 | Ens.1 | 6 - 4 - 3 - 9 | | Item 3 | Ens.1 | 3 - 2 - 7 - 9 | | |
| | Ens.2 | 7 - 2 - 8 - 6 | | | Ens.2 | 4 - 9 - 6 - 8 | | |
| | | Total Dígitos em Sentido Direto (Máximo = 16) | | | | Total Dígitos em Sentido Inverso (Máximo = 14) | | |
| | | | | | | Pontuação Total Obtida Sentido Direto + Sentido Inverso (Máximo = 30) | | |

**Figure IV** – Example of the Verbal Digital Test

### vii. Timed Up and Go (TUG)

TUG test involves the person getting up from a chair, walk three meters towards a brand and returning to the chair to sit. This test was applied to track functional mobility and fall risk of older adults. For this test, the generally accepted cut point is ≥ 14 seconds, which is an indicator of the fall risk. The older adults who complete the task in less than 20 seconds had a higher level of functionality (Shumway-Cook, Brauer, & Woollacoot, 2000).

The intra rater reliability observed in a pilot study performed in 5 subjects similar to the sample participants revealed excellent with an ICC= 0,94 (Fleiss, 1981).

### viii. Five Times Sit to Stand

To evaluate the postural control, balance, lower extremity strength, transitional movements, and fall risk it employed the Five Times Sit to Stand Test. According to the same author the cut point as an indicator of fall risk, was ≥ 15 seconds (Whitney et al., 2005).

Intra rater reliability observed in the pilot study was considered excellent with an ICC=0,99 (Fleiss, 1981).

### *ix. EMED NOVEL pressure platform*

To evaluate static balance it was used the EMED NOVEL pressure platform with connection to a computer. Emed-AT25 D, Novel Inc., Munich, Germany operates with calibrated capacitive sensors (0,5 $cm^2$ area), and which contained 4000 capacitive sensors within a sensing area of 380 x 240 $mm^2$ (sensor resolution of two sensors/$cm^2$), and had a 25 Hz recording frequency (Coelho, Fernandes, Santos, Paúl, & Fernandes, 2016).

The EMED NOVEL system has been the most used in barefoot plantar pressure studies (Castro, Soares, & Machado, 2014).

This test has been often used, not only by the good correlation between the center of pressure and platform (Lord, Menz, & Tiedemann, A physiological profile approach to falls risk assessment and prevention, 2003), but also for its usefulness in evaluating postural stability in older adults (Lord, Clark, & Webster, 1991, 1999).

## 2.4 Procedures

### i. Pilot Study

It's worth pointing out that, before the initial evaluation to the study's participants (M0), a pilot study was made, where the sociodemographic characterization questionnaire, the cognitive and physical tests (including the pressure platform) were applied. It was an initial evaluation, to 5 individuals, similar to the participants of the study. The objective was to identify possible flaws on the questionnaire comprehension, to verify the simplest way to apply them and to time each participant.

### ii. Data collection

Data collection occurred in the Pasteleira's Towers Residents Association. It was performed at two different times M0 and M1 with three months apart. On the pre (M0) and post intervention (M1) participants filled the sociodemographic characterization questionnaire (Alonso, Brech, Bouquin, & Greve, 2011).

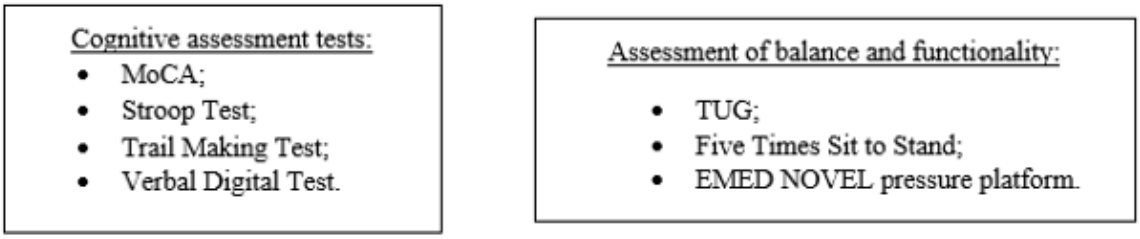


**Figure V**- Evaluation Instruments used in the study

All the scales and tests were used afterwards following the order seen in (Figure V).

It is important to mention that all the tests (cognitive and physical) were applied according to the rules of their respective authors. In all physical tests, participants were supervised by one of the researchers for security reasons.

The participants start by filling MoCA with one of researcher that ask the questions.

Stroop test was the next test, performed with the same researcher that, which in the first part each participant had the opportunity to train to then pass the test. This training consisted of the appointment and subsequently read, as fast as possible, four colors (pink, gray, blue and green) very similar to the test.

The second part was divided into "Color Reading" and "Color Nomination". In "Color Reading" each participant had 120 seconds to read the words aloud, starting in the first column, then the second, and so on, until the last word of the 4th column, a total of 112

words. The "Color Nomination" was very similar to the above with the difference that the participants had to say the color that was written the word.

In the TMT- parts A and B each participant received a shortened version of the test, for train and realize what was intended. Part A had circles numbered 1 through 25. The objective would be to connect all numbers in ascending order, through a line. In Part B, the circles understood numbers (1-13) and letters (A-L), the objective would be to switch between the number and letter (i.e. 1-A-2-B-3-C, etc.), and the numbers would have to be connected in ascending order and the letters in alphabetical order. In both parts of the test, the participant was instructed to connect the circles as fast as possible, without lifting the pen or pencil from the paper. If the participant made a mistake would be noticed immediately in order to allow its correction. Note that if the participant does not conclude both parts, after 300 seconds, there would be no need to end the test.

The last cognitive test was VDT. It notes that the digits have been read at a rate of one per second. In the Forward way sequences of random numbers (digits 2-9) were read to the subject, which had to repeat one at a time. This part consists of eight items, each item has two trials. In the Backward the sequences of numbers (from 2 to 8 digits) were read, so that participant repeated but in reverse order, this part consists of seven items each containing two trials.

TUG test was performed by each participant and time each participant takes to stand from a chair (of standardized arm chair, seat at approximately 46cm height, armchair at 65cm), walk a distance of 3 meters, and then walk back to the chair and sit again. The test was timed by a researcher, using a chronometer (seconds). The test was repeated three times and the average was used for data analysis. A relevant aspect is in case the participant didn't succeed in the first try (e.g. stopped when was supposed to go back to the chair, didn't immediately sit or didn't walk all the way to the 3 meters mark) participant always repeated the test. It was recommended to use participant own shoes when realizing the test. Then, the command "GO" was given and one of the researchers measured the time, with a chronometer (seconds). All the participants had the accompaniment all along the test route of a researchers for security purposes.

Five Times Sit to Stand Test consisted in raising and sitting five times in a chair, as quickly as possible. The test initiated and ended with the participant on the sitting position, with feet well placed on the ground, knees flexed at an approximately 90º angle, with their back well supported on the back of the chair and his arms crossed across the chest. The

chair used for the test had, the standard measures (43cm height and 47.5cm depth). Then, the command "GO" was given and one of the researchers measured the time, with a chronometer (seconds). The test was repeated three times and the average was used for data analysis.

After these tests, participants' static balance was evaluated with EMED NOVEL pressure platform.

At last each participant climbed to the pressure platform barefooted in their natural position, standing with Double Support. For static balance participants had to look to a mark on a wall placed at a 2 meters of the platform and at that position as still as possible for 60 seconds with eyes open and then eyes closed.

All the process of data collection from the pressure platform was executed by 2 researchers; while one was on the computer introducing the codes of each participant and activating the commands to start and stop the program, the other was always accompanying the participant through the tasks for security reasons. Adjustments were made where warranted.

Static Balance (SB) part consisted in 6 (performed randomly) trials with Double Support (DS) (Table I).

| | | Randomly Chosen | Trials |
|---|---|---|---|
| **Static Balance** | **Double Support** | Eyes Open | 3 |
| | | Eyes Closed | 3 |

**Table I**- Static Balance; Double Support (eyes open and closed)

### iii. Data Analysis

The application COP_Stats2 was used to collect data on COP displacement variables. The COP displacement variables was defined as CG - Global COP displacement maximal length (cm), Cx - Antero-posterior COP displacement maximal length (cm), Cy - Medio-lateral COP displacement maximal length (cm), VG - Global COP displacement maximal velocity ($cm^2$), Vx - Antero-posterior displacement COP maximal velocity ($cm^2$) and Vy - Medio-lateral COP displacement maximal velocity ($cm^2$).

### iv. Physical and Cognitive Exercise Program

Specific cognitive training had the duration of 12 weeks, twice a week, for approximately 1 hour orientated by 1 experienced researcher. All participants' attendances to the sessions were registered. All cognitive tasks applied during the 12 weeks, in a total of 22 sessions (Annex 7-CD). All the cognitive sessions, executive functions and number of exercises, their progression and respective week of each session are in Annex 8 and also in the (CD).

Both groups frequented the physical exercises program, with the objective of diminishing the risk of falls and increasing their functionality. This program had exercises divided in 4 main groups: flexibility, muscular endurance, reaction time and static and dynamic balance.

During cognitive training sessions the participants were seated in front of a big canvas were the cognitive exercises were projected for a few seconds, using power point software. The answers were given individually.

With regard to cognitive sessions in the 1st session held an exercise for cognitive flexibility and two for selective attention.

In the 2nd and 3rd sessions held an exercise for cognitive flexibility and two for selective attention, using the same exercises in the previous session.

In the 4th session held an exercise for cognitive and two for selective attention flexibility, using the same exercises in the previous session, but increased the difficulty.

In the 5th and 6th sessions took place two exercises for selective attention and one for sequencing and planning, only held two previous session exercises (increasing difficulty) and implemented a new exercise.

In the 7th session took place two exercises for cognitive flexibility and one for planning and sequencing, were introduced two exercises already used and has remained an also performed in the previous session.

At the 8th session took place two exercises cognitive flexibility and one for sequencing. Two of the exercises had already been used and added a third.

In the 9th session were three exercises, one for cognitive flexibility, one for sequencing and for working memory. Keep an exercise already used and added a new exercise.

In the 10th, 11th and 12th sessions were held three years, one for cognitive flexibility, one for sequencing and one for working memory and problem solving. There were used some of the exercises performed previously, but increased the difficulty.

In 13th session held an exercise for cognitive flexibility, one for sequencing and for selective attention and problem solving.

In 14th session were held three years, one for selective attention and problem solving and two for cognitive flexibility. They used some of the exercises performed previously, but increased the difficulty.

In the 15th and 16th sessions took place three years, two for selective attention and problem solving and one for cognitive flexibility. There were used some of the exercises performed previously, but increased the difficulty.

In the 17th 18th sessions held an exercise for working memory, one for working memory and cognitive flexibility and one for sequencing and planning.

At the 19th session showed up two exercises for cognitive flexibility and problem solving and one for problem solving and working memory. Three new exercises have been implemented.

At the 20th session presented an exercise for working memory, one for working memory and problem solving and one for cognitive flexibility and problem solving. Two new exercises were implemented and re-used up an exercise (higher difficulty level).

In the 21st were presented two exercises for selective attention and working memory and to cognitive flexibility. Only remained an exercise and added two new exercises.

Finally in the 22nd were presented three years, one for sequencing and working memory, a cognitive flexibility and another for sequencing and planning. Three new exercises have been implemented.

### v. Ethics

The study was received and admitted by the Ethics Committee of School of Health Sciences of Porto with the nº 051672016. Both the presidents of the school were asked for authorization to use the equipments.

It was delivered to all the participant on this study, an informed consent term according to the Helsínquia's Declaration, (Annex 1), in which they were informed their anonymity would be preserved and that the divulgation of the data would happen exclusively on the scientific environment. Each participant was given a random code, to be subsequently used in the database in order to all of them remain anonymous.

After the data collection, the participants were given the possibility to consult the results of their evaluation.

### vi. Statistic

For interferential descriptive statistical analysis the SPSS 23.0 software (*Statistical Package for Social Sciences®, IBM Portugal, Lisbon*) with a 0,05 significance level was utilized. Normality was verified through *Shapiro-Wilk* test. The variables did not follow a normal distribution, so the following tests were used for to identify statistical differences between moments Wilcoxon Test, for two related samples, was used and Mann-Whitney Test, for two independent samples, was used for intergroup comparisons.

For descriptive statistics appealed to the Median, as measure of central tendency, and the percentiles 25 and 75, as measures of dispersion (Marôco, 2010).

According to the (Cicchetti & Sparrow, 1981; Fleiss, 1981) the intra rater reliability observed in TUG test was excellent with an ICC= 0,94 and for Five Times Sit to Stand was excellent too, with an ICC=0,99.

# III. Results

It is important to note that a participant was removed as it was considered a severe outlier in order to make a more cohesive sample (participant nº5) of the IG.

## 3.1. Sample characterization

The final sample was composed by 17 participants divided in 2 groups (7 in the IG and 10 in the CG. The age, height and body weight variables were not statistically different ($p<0,05$) in the first moment (M0), so these groups could be compared (Table II).

**Table 1I – Sample characterization (m: meters; kg: kilograms)**

| | Groups | | | |
|---|---|---|---|---|
| | **Intervention** | **Control** | **Mann-Whitney U** | **p value** |
| **Age (years)** | 74,00 (63,00; 77,00) | 71,50 (68,00; 74,00) | -0,147 | p= 0,905 |
| **Height (m)** | 1,61 (1,59; 1,63) | 1,62 (1,47; 1,70) | -0,293 | p= 0,813 |
| **Body Weigth (kg)** | 70,50 (53,60; 74,40) | 70,55 (62,32; 80,82) | -0,489 | p= 0,653 |

**Median ($P_{25}$ ; $P_{75}$)**

## 3.2. Cognitive tests

In the cognitive tests, there were no statistical significant differences between moments nor between groups.

Nevertheless, it can be seen that the IG increased MoCA score after the 12 weeks of cognitive training, while the CG decreased the total score. Moreover Verbal Digital Test total score decreased after the 12 weeks in both groups. The Stroop Nomination-Total Correct Words and Incorrect Words were variables that presented differences in M0 between groups so they were not analyzed in M1 (Table III).

When analyzing both parts of the TMT, it can be seen that the cognitive training program did not have any effect on the percentage of IG participants that complete the test Part A. Nevertheless, on Part B, when the participants had to switch between the number and letter, the percentage of IG participants that complete the test was greater after 12 weeks than at the beginning of the program. The percentage of CG participants that complete the test were always greater than the IG in Part A but not in part B (Table IV).

Note that was averaging accession after the intervention of the IG and obtained 89,6% to 100%.

**Table 2II – Statistical Results of the comparison between moments and groups of MoCA, Stroop Nomination (Total Correct Words and Incorrect Words) and VDT)**

| | | Moments | | Between Moments | | Between Groups M0 | | Between Groups M1 | |
|---|---|---|---|---|---|---|---|---|---|
| | | M0 | M1 | Wilcoxon Z | p value | Mann-Whitney | p value | Mann-Whitney | p value |
| MoCA- Score | IG | 22,00 (20,00; 24,00) | 24,00 (20,00; 25,00) | -0,946 | p= 0,406 | -1,728 | p= 0,087 | -0,393 | p= 0,721 |
| | CG | 25,00 (22,00; 26,25) | 23,50 (20,00; 26,50) | -0,615 | p= 0,586 | | | | |
| Stroop Nominatio- Total Correct Words | IG | 56,00 (44,00; 61,00) | 47,00 (36,00; 64,00) | -0,338 | p= 0,813 | -2,346 | **p= 0,017** | -2,298 | p= 0,020 |
| | CG | 79,00 (67,50; | 88,50 (67,50; | -0,663 | p= 0,543 | | | | |
| Stroop Nominatio- Incorrect Words | IG | 4,00 (3,00; 13,00) | 1,00 (1,00; 3,00) | -1,992 | p= 0,063 | -2,083 | **p= 0,037** | -0,862 | p= 0,392 |
| | CG | 1,00 (0,00; 2,50) | 0,50 (0,00; 4,25) | -0,497 | p= 0,633 | | | | |
| Verbal Digital Test- Total Score (VDT) | IG | 10,00 (7,00; 13,00) | 9,00 (3,00; 19,00) | 0,000 | p= 1,000 | -1,423 | p= 0,168 | -0,886 | p= 0,398 |
| | CG | 15,00 (10,75; 18,50) | 14,50 (9,50; 19,00) | -0,770 | p= 0,508 | | | | |

**Median ($P_{25}$ ; $P_{75}$)**

***IG:*** *Intervention Group;* ***CG:*** *Control Group;* ***M0:*** *Moment 0;* ***M1:*** *Moment 1*

**Table 3V – Statistical Results of the comparison between groups of the Trail Making Teste (Part A and Part B)**

| | | | Groups IG (n=7) | Groups CG (n=10) |
|---|---|---|---|---|
| Trail Making Test-Part A (TMT) | M0 | Yes | 57 (%) | 90 (%) |
| | | No | 43 (%) | 10 (%) |
| | M1 | Yes | 43 (%) | 80 (%) |
| | | No | 57 (%) | 20 (%) |
| Trail Making Test-Part B (TMT) | M0 | Yes | 43 (%) | 20 (%) |
| | | No | 57 (%) | 80 (%) |
| | M1 | Yes | 57 (%) | 30 (%) |
| | | No | 43 (%) | 70 (%) |

***IG:*** *Intervention Group;* ***CG:*** *Control Group;* ***M0:*** *Moment 0;* ***M1:*** *Moment 1;* ***Yes:*** *The participants were able to do the TMT (A+B) until the 300 seconds;* ***No:*** *The participants failed to ferformed the TMT (A+B) until the 300 seconds*

### 3.3. TUG test and Five Times Sit to Stand test

In the TUG test there were no statistical differences between moments nor between groups. In relation to Five times Sit to Stand Test after the 12 weeks there statistical differences between moments, but there weren´t any between groups.

Nevertheless, it can be seen, in TUG, Test that IG spend in average less time than the CG performing TUG.

In Five Times Sit to Stand both groups spent more time to do the test after the cognitive training program, with CG doing it significantly slower (Z= - 2,090; **p=0,037**) (Table V).

**Table V – Statistical Results of the comparison between moments and groups of the Timed Up and Go Test and Five Times Sit to Stand**

| | | | | | | Between Groups | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Moments | | Between Moments | | M0 | | M1 | |
| | | M0 | M1 | Wilcoxon Z | p value | Mann-Whitney U | p value | Mann-Whitney U | p value |
| **Timed Up and Go Test** | IG | 9,05 (7,65; 9,39) | 8,43 (7,49; 9,21) | -0,507 | p= 0,688 | -0,586 | p= 0,601 | 0,000 | p= 1,000 |
| | CG | 8,11 (7,02; 9,66) | 8,60 (7,46; 9,37) | -0,255 | p= 0,846 | | | | |
| **Five Times Sit to Stand** | IG | 9,83 (8,45; 11,25) | 10,51 (9,21; 12,87) | -1,183 | p= 0,297 | -0,976 | p= 0,364 | -0,878 | p= 0,417 |
| | CG | 8,99 (7,41; 10,18) | 9,53 (7,94; 10,82) | -2,09 | **p= 0,037** | | | | |

**Median ($P_{25}$ ; $P_{75}$)**

***IG:*** *Intervention Group;* ***CG:*** *Control Group;* ***M0:*** *Moment 0;* ***M1:*** *Moment 1*

### 3.4. Double Support with Eyes Open

There were no statistical differences in Double Support with Eyes Open between groups, neither between moments in each group in the variables analyzed (Table VI).

Moreover, when analysing and comparing the M1 variables values with M0 there was an increase in the IG in all variables after 12 weeks of intervention. Nevertheless in CG variables values showed a decrease in all variables of COP displacement except in Cy in M1 when compared with M0.

**Table VI – Statistical Results of the comparison between moments and groups in Double Support with Eyes Open in IG and CG**

| | | Moments | | | Between Moments | Between Groups | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | M0 | M1 | M1-M0 |
| | | M0 | M1 | Dif M1-M0 | p value | p value | p value | p value |
| CG-Global COP displacement length (cm) | IG | 22,06 (18,76; 26,31) | 22,43 (21,24, 27,14) | 0,37 | p= 0,237 | p= 0,962 | p= 0,601 | p= 0,327 |
| | CG | 22,83 (15,58; 32,11) | 21,71 (17,31; 31,17) | -1,12 | p= 0,959 | | | |
| Cx-Antero-posterior COP displacement length (cm) | IG | 10,12 (9,81; 14,94) | 13,20 (9,57; 14,15) | 3,08 | p= 0,735 | p= 0,887 | p= 0,417 | p= 0,417 |
| | CG | 12,02 (8,90;14,60) | 10,91 (9,17, 12,61) | -1,11 | p= 0,241 | | | |
| Cy-Medio-lateral COP displacement length (cm) | IG | 17,61 (14,46; 18,37) | 18,84 (18,11; 20,80) | 1,23 | p= 0,091 | p= 0,962 | p= 0,536 | p= 0,364 |
| | CG | 16,36 (10,16; 23,32) | 16,53 (12,30; 24,79) | 0,17 | p= 0,333 | | | |
| VG- Global COP displacement maximal velocity ($cm^2$) | IG | 2,46 (2,10; 2,60) | 2,87 (2,46, 3,14) | 0,41 | p= 0,091 | p= 0,813 | p= 0,315 | p= 0,103 |
| | CG | 2,81 (1,53, 3,93) | 2,29 (1,89; 3,45) | -0,52 | p= 0,959 | | | |
| Vx- Antero-posterior COP displacement maximal velocity ($cm^2$) | IG | 1,59 (1,23; 2,44) | 1,84 (1,12; 2,53) | 0,25 | p= 0,398 | p= 0,962 | p= 0,364 | p= 0,133 |
| | CG | 1,51 (1,26; 2,33) | 1,49 (1,31; 1,62) | -0,02 | p= 0,059 | | | |
| Vy- Medio-lateral COP displacement maximal velocity ($cm^2$) | IG | 2,26 (2,09; 2,52) | 2,37 (2,11; 3,09) | 0,11 | p= 0,398 | p= 0,237 | p= 0,475 | p= 0,906 |
| | CG | 2,27 (1,34; 3,69) | 2,14 (1,60; 3,32) | -0,13 | p= 0,646 | | | |

**Median ($P_{25}$ ; $P_{75}$)**

***IG:*** *Intervention Group;* ***CG:*** *Control Group;* ***M0:*** *Moment 0;* ***M1:*** *Moment 1;* ***M1-M0*** *; Moment 1 less Moment 0;* ***Dif :*** *variable difference*

### 3.5. Double Support with Eyes Closed

After 12 weeks of cognitive training, and considering the variables values' difference between M1 and M0, there was significant differences between groups and moments (Table VII).

In fact, IG showed that the values of the difference between M1 and M0 in Cy, Vx and Vy were significantly higher when compared with CG respectively **p=0,025**, **p=0,042** and **p=0,025**.

In the Double Support with Eyes Closed, IG showed always higher values in the cinematic variables at baseline as well after 12 weeks of cognitive training when compared with CG.

**Table VII – Statistical Results of the comparison between moments and groups in Double Support with Eyes Closed in IG and CG**

| | | Moments | | | Between Moments | Between Groups | | |
|---|---|---|---|---|---|---|---|---|
| | | M0 | M1 | Dif M1-M0 | p value | M0 p value | M1 p value | M1-M0 p value |
| CG-Global COP displacement length (cm) | IG | 32,69 (26,75; 33,44) | 30,28 (29,35; 30,61) | -2,41 | p= 0,499 | p= 0,270 | p= 0,601 | p= 0,070 |
| | CG | 21,50 (16,42; 36,57) | 25,50 (18,40; 30,27) | 4,00 | p= 0,059 | | | |
| Cx-Antero-posterior COP displacement length (cm) | IG | 13,69 (10,77; 19,98) | 14,42 (12,32; 17,28) | 0,73 | p= 0,866 | p= 0,193 | p= 0,536 | p= 0,417 |
| | CG | 10,32 (8,39; 18,26 ) | 13,20 (11,39; 19,23) | 2,88 | p= 0,093 | | | |
| Cy-Medio-lateral COP displacement length (cm) | IG | 23,32 (22,43; 27,40) | 23,82 (18,76; 25,32) | 0,50 | p= 0,128 | p= 0,230 | p= 0,669 | **p= 0,025** |
| | CG | 16,77 (14,42;26,89) | 19,12 (12,03; 30,38) | 2,35 | p= 0,139 | | | |
| VG- Global COP displacement maximal velocity ($cm^2$) | IG | 3,51 (2,86; 4,30) | 3,47 (2,82; 3,73) | -0,04 | p= 0,499 | p= 0,109 | p= 0,740 | p= 0,109 |
| | CG | 2,28 (1,64; 3,69) | 2,90 (1,98; 4,41) | 0,62 | **p= 0,022** | | | |
| Vx- Antero-posterior COP displacement maximal velocity ($cm^2$) | IG | 2,00 (1,67; 3,12) | 1,89 (1,51; 2,50) | -0,11 | p= 0,499 | p= 0,161 | p= 0,962 | **p= 0,042** |
| | CG | 1,39 (1,02; 2,28) | 1,69 (1,52; 2,84) | 0,3 | **p= 0,017** | | | |
| Vy- Medio-lateral COP displacement maximal velocity ($cm^2$) | IG | 3,18 (2,72; 3,82) | 3,10 (2,62; 3,53) | -0,08 | p= 0,237 | p= 0,193 | p= 0,887 | **p= 0,025** |
| | CG | 2,21 (1,54; 3,41) | 2,70 (1,51; 4,06) | 0,49 | p= 0,059 | | | |

**Median ($P_{25}$ ; $P_{75}$)**

***IG:*** *Intervention Group;* ***CG:*** *Control Group;* ***M0:*** *Moment 0;* ***M1:*** *Moment 1;* ***M1-M0*** *; Moment 1 less Moment 0;* ***Dif :*** *variable difference*

### 3.6. Comparison Between eyes open and closed in IG

Comparing the values of the variables in with "Eyes Open" and "Eyes Closed" in IG, there were significant differences in M0 and M1 (Table VIII). It was revealed in the beginning of the program that closing the eyes increased significantly all the COP variables ($p<0,05$) except Vx.

After 12 weeks of cognitive training closing the eyes increased significantly all the variables for COP displacement length ($p<0,05$). Nevertheless, the variables related to COP velocity showed and improvement or a stabilization but not significant (Table VIII).

**Table VIII – Statistical Results of the comparison between moments in Double Support with Eyes Open and Eyes Closed in IG**

| | Between Moments | | | | | |
|---|---|---|---|---|---|---|
| | M0 | | | M1 | | |
| | Eyes Open | Eyes Closed | p value | Eyes Open | Eyes Closed | p value |
| **CG - Global COP displacement length (cm)** | 22,83 | 32,69 | **0,003** | 25,43 | 30,28 | **0,00000** |
| **Cx - Antero-posterior COP displacement length (cm)** | 10,12 | 13,69 | **0,018** | 13,20 | 14,42 | **0,028** |
| **Cy - Medio-lateral COP displacement length (cm)** | 17,61 | 23,32 | **0,018** | 18,84 | 23,82 | **0,028** |
| **VG - Global COP displacement maximal velocity ($cm^2$)** | 2,46 | 3,51 | **0,018** | 2,87 | 3,47 | 0,310 |
| **Vx -Antero-posterior COP displacement maximal velocity ($cm^2$)** | 1,59 | 2,00 | 0,237 | 1,84 | 1,84 | 0,499 |
| **Vy - Medio-lateral COP displacement maximal velocity ($cm^2$)** | 2,26 | 3,18 | **0,018** | 2,37 | 3,10 | 0,237 |

***M0*** *-Moment 0;* ***M1*** *-Moment 1*

### 3.7. Comparison Between eyes open and closed in CG

Comparing the values of the variables in with "Eyes Open" and "Eyes Closed" in CG, there were no significant differences in M0, but there were in M1. So, after 12 weeks when the CG participants closed the eyes there was a significant increase in all the variables ($p<0,05$) except in Vy (Table IX).

In CG, at baseline, it was observed that when participants close the eyes it did not interfere significantly in all COP variables, showing a generalized decrease except in Cy.

**Table IX – Statistical Results of the comparison between moments in Double Support with Eyes Open and Eyes Closed in CG**

| | Between Moments | | | | | |
|---|---|---|---|---|---|---|
| | M0 | | | M1 | | |
| | Eyes Open | Eyes Closed | p value | Eyes Open | Eyes Closed | p value |
| **CG - Global COP displacement length (cm)** | 22,83 | 21,5 | 0,169 | 21,71 | 25,50 | **0,007** |
| **Cx - Antero-posterior COP displacement length (cm)** | 12,02 | 10,32 | 0,508 | 10,91 | 13,20 | **0,005** |
| **Cy - Medio-lateral COP displacement length (cm)** | 16,36 | 16,71 | 0,203 | 16,53 | 19,12 | **0,047** |
| **VG - Global COP displacement maximal velocity ($cm^2$)** | 2,81 | 2,28 | 0,721 | 2,29 | 2,90 | **0,017** |
| **Vx -Antero-posterior COP displacement maximal velocity ($cm^2$)** | 1,51 | 1,39 | 0,333 | 1,49 | 1,69 | **0,037** |
| **Vy - Medio-lateral COP displacement maximal velocity ($cm^2$)** | 2,27 | 2,21 | 0,508 | 2,14 | 2,73 | 0,114 |

***M0*** *-Moment 0;* ***M1*** *-Moment 1*

# IV. Discussion

The purpose of this study was to examine the influence of a cognitive exercise program in static balance in older adults and static balance.

It came clear that cognitive training had no influence on cognitive tests (MoCa, Stroop Test, VDT and TMT) and the TUG test, because there were no significant differences between moments or groups in these variables. However, there were significant differences between Five Times Sit to Stand in CG. There were no significant differences between groups or moments in Double Support with "Eyes Open" in both groups, but at the Double Support with "Eyes Closed" there were significant differences between moments or groups. Finally, in the comparison between Eyes Open and Eyes Closed in IG was found that, there were significant differences in M0 and M1, but in CG only significant differences were found after 12 weeks of intervention the cognitive exercise program.

Although there has been no significantly statistic difference between moments or groups, it was possible to verify that after 12 weeks of intervention IG revealed an increase in total MoCA score when compared with CG. These results are according with Apóstolo, Rosa, and Castro (2011) that found after a cognitive training of 7 weeks, an improvements in MoCA score.

In VDT no significant differences after 12 weeks there was a decrease in both groups which was not expected. This decrease in both groups was also observed in the results obtained in studying Banhato and Nascimento (2007), which evaluated the executive functions of 346 older adults through five tests, one of the VDT, and the authors found that executive functions decline with age, once the working memory is one of the most important executive function evaluated in the VDT, consequently it will be affected. Another reason given by Lezark et al. (2004), the reduction in the IG and CG in VDT, may have been the fact that during the test participants were subjected to stress, damaging your attention, which in turn may have influenced the results.

There were no significant differences in the TMT after the intervention in both groups, but there was a decrease in the percentage of IG and CG participants that concluded TMT- Part A in M1. However, in the TMT- Part B, there was noted an increased in IG participants' percentage that complete the test after 12 weeks of intervention but not in CG participants' percentage. In Part B participants had to switch between the number and letter implying including a higher cognitive flexibility in IG participants, perhaps a reflex of the cognitive training program.

There were no differences between groups in the TUG test after 12 weeks of intervention, which was unexpected as cognitive training was demonstrated by the study van Iersel, Munneke, Esselink, Benraad, & Rikkert (2007), which consisted of a sample of 85 older adults with a median age 75,8 years, who assessed the functional mobility through the TUG, which showed improvements in gait speed. Nevertheless, it cannot be forgotten that both groups participated in a specific exercise program to prevent fall risk factors, in which similar exercises were inserted.

Nevertheless, if the absolute values are analyzed it can be seen that IG spend less time than the CG whit goes against the results obtained by the authors Steffen, Hacker, & Mollinger (2002) which consisted of a sample of 95 older adults, aged 61 and 89, evaluating the speed of the march through 4 clinical trials, one was TUG test, obtaining an observation of high results.

Only the CG showed statistically significant differences in Five Times Sit to Stand. However, this result was not expectable, once both groups performed the same specific exercise program. Perhaps the fact that the performed as quickly as possible could stress the participants. On the other hand, according to Whitney et al. (2005), the movement was done in a standard chair being not possible to adjust its height chair to each participant's height. This means that each subject had to increase or decrease the bending and angular velocity to overcome the odds of having a lower or higher chair which could interfere in the test (Schenkman, Riley, & Pieper, 1996). Furthermore, the fact that the IG had increased the time taken to perform the Five Times Sit to Stand, may mean that the cognitive intervention program will not produce the effects required for the IG improved the execution time of the test.

Analysing the cinematic variables with "eyes open" it was not observed any differences between the groups after the 12 weeks cognitive training program. Even more, IG increased the values of COP displacement, meaning that the static balance decreased according to Winter, Patla, Prince, Ishac, and Gielo-Perczak (1998), which was unexpected. The evidence shows positive results with cognitive training program in static balance variables (Li et al., 2010). However, according to Laughton et al. (2003) there was a significant increase in COP velocity in the IG, and this increase leads to a higher requirement of postural control. So, it seems that 12 weeks of cognitive training had no influence on cinematic variables in Double Support with Eyes Open. Perhaps if would be necessary more weeks of intervention to achieve cinematic significant results.

There are significant differences between moments and groups (M1-M0) with “Eyes Closed” after 12 weeks of intervention. There was an increase in COP displacement variables and a decrease in the COP velocity variables in general in IG, when compared with baseline values.

The increase in COP displacement may be explained by the fact that when visual system is out of the systems responsible for balance, participants use a compensatory strategy coming from the ankles what can be the cause of increasing the length of COP displacement (Kalisch, Kattenstroth, Noth, Tegenthoff, & Dinse, 2011). The significant decrease of Cy (Medial-lateral) in the variable difference between groups reflects the former possible explanation.

COP velocity variables decreased after 12 weeks in IG groups, perhaps being related to an increase in attention in postural control mechanisms (due to the cognitive training program) when the eyes are closed. This supposition is corroborated by the significant differences between the variables difference of Vx (Antero-posteririor) and Vy (Medio-lateral) between both groups (Raymakers, Samson, & Verhaar, 2005).

There were significant differences in M0 and M1 in the comparison between Eyes Open and Eyes Closed in IG. The IG participants in the baseline showed a significant increase in length and the maximum speed of the COP displacement when they closed the eyes showing an instability. This was expected, demonstrating the importance of the visual system on postural control and specifically the balance (Shumway-Cook and Hoollacott (2007). Nevertheless, it is interesting that when closing the eyes this group had no significant differences in COP displacement velocity, meaning that perhaps something was better in their postural control that could control an expected increase when the eyes were closed. As can be seen in the study Raymakers et al. (2005) that analyzed postral control, using the COP through a static force platform, comparing two groups; the first of healthy adults (n = 45, age 21-45 years) and older healthy adults (n = 38, age 61-78 years) and second with two groups of healthy older adults (n = 10 and n = 21 , age 65-89 years). Evaluated mean displacement velocity, maximal range of movement along x- and y-co-ordinates.

Finally, the CG only in M1 were no significant differences between eyes open and closed. The CG behaved as expected, since increased kinematic variables as she closed her eyes as can be seen in the study mentioned earlier (Shumway-Cook & Hoollacott, 2007).

Therefore, it can be concluded when the IG and CG close their eyes there were significant differences in balance, and which could be related to the fact that it is a more complex task, so needs more attentional resources; for example, when participants perform the Double Support with the eyes open, they use the visual system to help balance themselves, while with eyes

closed this doesn't happen. Therefore it is necessary to be more attentive. According to the literature Coelho et al. (2016) the executive functioning influences the balance mostly more complex tasks.

In addition, the IG did not present a declining COP displacement, while the CG decreases the COP displacement, possibly due to gains in terms of executive functioning, including selective attention and planning, as a result of training.

The limitations of this study were undoubtedly the small sample size, the time of intervention and withdrawal of two participants, but for time and motivational reasons eventually abandoned the procedure. The reason for which participants have left the study through the intervention, may have been the lack of greater variety of exercises.

Also there were verified that both groups performed regular exercise, which may have been a major factor causing the bias in the results of cognitive training program.

Significant differences were not observed with the application of cognitive tests, adding to another major limitation in pre and post intervention assessment thus, the cognitive tests are not sensitive enough because only found these differences to assess the influence of the COP displacement in the balance.

One of the limitations to statistical level was the analysis of the variables divided into several statistical tests rather than just one, and enlarges the type 1 error.

However, despite the withdrawal of two participants at the end of the intervention gave a percentage of 89.6% attendance of older adults that were maintained over the 12-week intervention.

## V. Conclusion

The cognitive exercise program implemented for 12 weeks, 2 times a week, and in order to improve executive functions seemed to have some influence in postural control strategies but not in static balance specifically.

For future studies it is important to use participants without regular physical exercise and to extend in time the cognitive program. For investigations would be interesting to increase the number of sessions per week, as in this study was twice a week, which could not have been enough for improvement in executive functioning.

It's important that in future studies, cognitive sessions should be more dynamic as in using more interactive game, promoting more interest from the participants that could lead to a reduction in matter of quitting rates.

The balance of the participants of the control group declined between assessments, whereas there were no differences in the balance of the participants of the intervention group. This may have been consequences from gains in executive function as a consequence of the cognitive training. However, the results of the present study are limited, and further research is required.

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# VII. Annexes

**Annex 1 –** Informed consent form in Portuguese

## Declaração de consentimento informado

Conforme alei 67/98 de 26 de Outubro e a "Declaração de Helsínquia" da Associação Médica Mundial (Helsínquia 1964; Tóquio 1975; Veneza 1983; Hong Kong 1989; Somerset West 1996, Edimburgo 2000; Washington 2002, Tóquio 2004, Seul 2008, Fortaleza 2013)

**Designação do Estudo:** A influência do treino cognitivo no equilíbrio em Adultos mais velhos

Eu, abaixo-assinado, _____ fui formado de que o estudo de investigação acima mencionado se destina a estudar a influência das tarefas cognitivas no equilíbrio.

Sei que neste estudo está prevista a realização de questionários, avaliações físicas (peso, altura, equilíbrio) e avaliações cognitivas tendo-me sido explicado em que consistem.

Foi-me garantido que todos os dados relativos à identificação dos participantes neste estudo são confidenciais e que será mantido o anonimato.

Sei que posso recusar-me a participar ou interromper a qualquer momento a participação no estudo, sem nenhum tipo de penalização por este facto.

Compreendi a informação que me foi dada, tive oportunidade de fazer perguntas e as minhas dúvidas foram esclarecidas.

Aceito participar de livre vontade no estudo acima mencionado.

Também autorizo a divulgação dos resultados obtidos no meio científico, garantindo o anonimato.

Nome dos Investigadores e Contactos:

Data ___/___/_____ Assinatura _____

**Annex 2 –** Sociodemographic characterization questionnaire (Portuguese version)

ESTSP | POLITÉCNICO DO PORTO

**Escola Superior de Tecnologia e Saúde do Porto**

Este destina-se a analisar a influência do Treino Cognitivo no Equilíbrio em Adultos mais Velhos fazendo parte da Linha de Investigação da ATC de Fisioterapia, "Envelhecimento".

As questões que se seguem pedem-lhe informações sobre os seus dados pessoais e a sua opinião sobre alguns aspetos da sua saúde.

**Classe de Exercícios para Adultos Mais Velhos**

**Questionário**

**Identificação**

1. Nome: _____
2. Data de nascimento: ___ / ___ / ___
3. Sexo: Masculino ☐ Feminino ☐
4. Estado Civil:
   Solteiro (a) ☐ Viúvo (a) ☐
   Casado(a) ☐ Divorciado/Separado(a) ☐
5. Quantos anos estudou? _____
6. Vive sozinho? Sim ☐ Não ☐
7. Qual a sua altura (m)? _____
8. Qual o seu peso (kg)? _____
9. Há quantos anos frequenta este programa de exercícios? _____

**Historia Clinica Actual**

10. Tem algum problema grave de saúde? Sim ☐ Não ☐
    10.1 Qual/ Quais?
    _____
    _____
    _____
    _____
11. Toma medicação? Sim ☐ Não ☐
    11.1 Qual?
12. Considera que atualmente a sua saúde é: Muito Má ☐ Má ☐ Razoável ☐
    Boa ☐ Excelente ☐
13. Tem medo de cair? Sim ☐ Não ☐
14. Esse medo de cair impede-o de realizar alguma(s) das suas atividades diárias?
    Sim ☐ Não ☐
    14.1 Se sim, qual (ais)? _____
15. Caiu nos últimos 6 meses? Sim ☐ Não ☐
    15.1 Por que caiu? Desequilibrei-me ☐ Escorreguei ☐ Tropecei ☐
    Tonturas ☐ Senti fraqueza nas pernas ☐ Outro ☐
    15.2 Magoou-se? Sim ☐ Não ☐
    Se sim, onde?_____
16. Como considera o seu equilíbrio quando se encontra em pé, mas parado?
    Muito Mau ☐ Mau ☐ Razoável ☐ Bom ☐ Excelente ☐
17. Como considera o seu equilíbrio quando se encontra a andar?
    Muito Mau ☐ Mau ☐ Razoável ☐ Bom ☐ Excelente ☐

**Exercício físico**

18. Como se desloca no seu dia-a-dia?
    A pé ☐ Transportes públicos ☐ Automóvel ☐
19. Além da ginástica na Associação duas vezes por semana, faz mais algum exercício físico? Sim ☐ Não ☐
    Se sim, qual? Quanto tempo? Quantas vezes por semana?
    _____

**Treino de atividades cognitivas**

20. Faz:
    ☐ Palavras cruzadas
    ☐ Sopa de letras
    ☐ Sudoku
    ☐ Jogar às cartas
    ☐ Outro?_____

**Muito obrigada pela sua colaboração!**

**Annex 3–** Montreal Cognitive Assessment (MoCA) version 7.3 (Portuguese version)

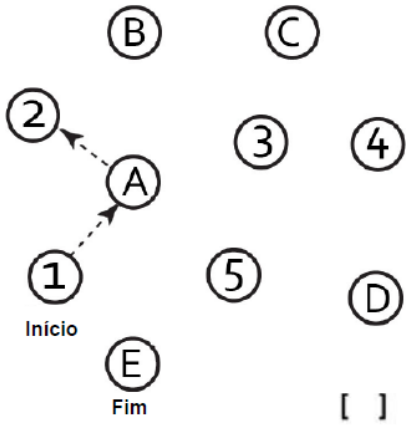
## MONTREAL COGNITIVE ASSESSMENT (MOCA)

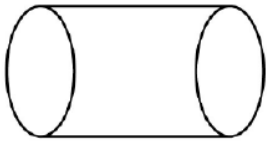
VERSÃO PORTUGUESA 7.3 – VERSÃO ALTERNATIVA

Nome: _____ Idade: _____
Género: _____ Data de Nascimento: _____
Escolaridade: _____ Data de Avaliação: _____

**VISUO-ESPACIAL / EXECUTIVA**

Copiar o cilindro



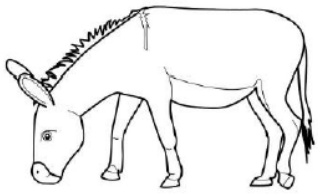
[ ] [ ]

Desenhar um Relógio (nove e dez) (3 pontos)

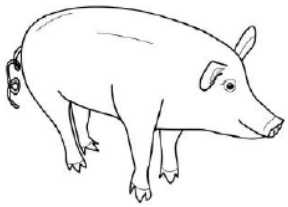
[ ] Contorno [ ] Números [ ] Ponteiros

Pontos: __/5

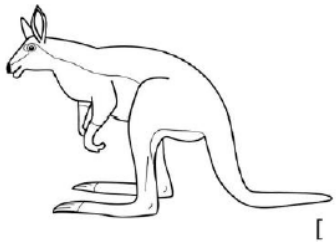
**NOMEAÇÃO**



[ ]



[ ]



[ ]

__/3

**MEMÓRIA**

Leia a lista de palavras. O sujeito deve repeti-la. Realize dois ensaios. Solicite a evocação da lista **5 minutos mais tarde.**

| | Barco | Ovo | Calças | Sofá | Roxo |
|---|---|---|---|---|---|
| 1º ensaio | | | | | |
| 2º ensaio | | | | | |

Sem Pontuação

**ATENÇÃO**

Leia a sequência de números. (1 número/segundo)

O sujeito deve repetir a sequência. [ ] 5 4 1 8 7

O sujeito deve repetir a sequência na ordem inversa. [ ] 1 7 4

__/2

Leia a série de letras (1 letra/segundo). O sujeito deve bater com a mão cada vez que for dita a letra A. Não se atribuem pontos se ≥ 2 erros.

[ ] F B A C M N A A J K L B A F A K D E A A A J A M O F A A B

__/1

Subtrair de 7 em 7 começando em 80. [ ] 73 [ ] 66 [ ] 59 [ ] 52 [ ] 45

4 ou 5 subtracções correctas: **3 pontos**; 2 ou 3 correctas: **2 pontos**; 1 correcta: **1 ponto**; 0 correctas: **0 pontos**

__/3

**LINGUAGEM**

Repetir: Ela soube que o advogado dele meteu um processo após o acidente. [ ]

As meninas a quem deram muitos doces ficaram com dores de barriga. [ ]

__/2

Fluência verbal: Dizer o maior número possível de palavras que comecem pela letra "M" (1 minuto). [ ]____ (N ≥ 11 Palavras)

__/1

**ABSTRACÇÃO**

Semelhança p.ex. entre banana e laranja = frutos [ ] olho - ouvido [ ] trompete - piano

__/2

**EVOCAÇÃO DIFERIDA**

| | Barco | Ovo | Calças | Sofá | Roxo |
|---|---|---|---|---|---|
| Deve recordar as palavras **SEM PISTAS** | [ ] | [ ] | [ ] | [ ] | [ ] |
| Opcional – Pista de categoria | | | | | |
| Opcional – Pista de escolha múltipla | | | | | |

Pontuação apenas para evocação **SEM PISTAS**

__/5

**ORIENTAÇÃO**

[ ] Dia do mês [ ] Mês [ ] Ano [ ] Dia da semana [ ] Lugar [ ] Localidade

__/6

Adapted by : Z. Nasreddine MD, N. Phillips PhD, H. Chertkow MD

 www.mocatest.org

Examinador: _____

**TOTAL** __/30

Versão Portuguesa: Freitas, S., Simões, M. R., Santana, I., Martins, C. & Nasreddine, Z. (2013). *Montreal Cognitive Assessment (MoCA): Versão 3*. Coimbra: Faculdade de Psicologia e de Ciências da Educação da Universidade de Coimbra.

**Annex 4 –** Stroop Test (Portuguese version)

## Pré-Teste

## Reconhecimento de Cor

**Instruções ao participante:** Vou pedir-lhe para fazer umas tarefas com palavras escritas a cor. Vamos começar por ver as cores [apresentar a Folha de Reconhecimento de Cor]. Esta aqui é [verde], esta [azul], [cinza] e [rosa]. (Marque com um visto √ se a resposta for pronta e sem hesitação, e/ou assinale quaisquer dificuldades).

**RECONHECIMENTO DE COR**

1 Verde ____
2 Azul ____
3 Cinza ____
4 Rosa ____

Observações:
_____

_____

## Treino de Leitura e de Nomeação de Cor

**Instruções ao participante:** Agora vamos ver as palavras [apresentar a Folha Treino de Leitura e Nomeação]. Estão escritas nas cores que vimos há pouco [retreinar a nomeação de cor se necessário]. Queria que me lesse estas palavras em voz alta, o mais depressa possível.

**RECONHECIMENTO DE COR**

1 Rosa _____
2 Cinza _____
3 Verde _____
4 Azul _____

Observações:
_____
_____

**NOMEAÇÃO DE COR** (a fazer só depois da Leitura de Palavras)

1 Cinza _____
2 Azul _____
3 Rosa _____
4 Verde _____

Observações:
_____
_____

XXXX

XXXX

XXXX

XXXX

ROSA

CINZA

VERDE

AZUL

| Nome: | Idade: | Escolaridade: |
|---|---|---|
| Data: | | |

**Leitura de Palavras: Folha de Registo**

**Instruções ao particiante:** Agora temos aqui mais palavras escritas. Queria que me lesse estas palavras em voz alta, o mais depressa que puder. Comece no início da 1.ª coluna, quando acabar passe à 2.ª, depois à 3.ª, e finalmente à última. Se se enganar, corrija e continue. Depois de eu dizer "Agora", comece. Entendido? Então atenção: Agora!

**Tempo:** Dê o sinal de partida ao mesmo tempo que aciona o cronómetro. O tempo limite é de **120 segundos**.

| | | | |
|---|---|---|---|
| 1 AZUL_____ | 29 VERDE____ | 57 ROSA_____ | 85 VERDE____ |
| 2 VERDE____ | 30 AZUL_____ | 58 VERDE____ | 86 CINZA____ |
| 3 ROSA_____ | 31 ROSA_____ | 59 AZUL_____ | 87 ROSA_____ |
| 4 CINZA____ | 32 AZUL_____ | 60 CINZA___ | 88 CINZA____ |
| 5 VERDE____ | 33 CINZA____ | 61 ROSA_____ | 89 AZUL____ |
| 6 AZUL_____ | 34 ROSA_____ | 62 CINZA____ | 90 CINZA____ |
| 7 ROSA_____ | 35 VERDE____ | 63 AZUL_____ | 91 VERDE____ |
| 8 CINZA____ | 36 CINZA____ | 64 CINZA____ | 92 ROSA_____ |
| 9 ROSA_____ | 37 VERDE____ | 65 ROSA_____ | 93 VERDE____ |
| 10 AZUL_____ | 38 AZUL_____ | 66 AZUL_____ | 94 ROSA_____ |
| 11 ROSA_____ | 39 ROSA_____ | 67 ROSA_____ | 95 AZUL_____ |
| 12 CINZA____ | 40 CINZA____ | 68 CINZA____ | 96 VERDE____ |
| 13 AZUL_____ | 41 VERDE____ | 69 AZUL_____ | 97 CINZA____ |
| 14 CINZA____ | 42 ROSA_____ | 70 VERDE____ | 98 AZUL_____ |
| 15 ROSA_____ | 43 AZUL_____ | 71 CINZA____ | 99 VERDE____ |
| 16 AZUL_____ | 44 VERDE____ | 72 AZUL_____ | 100 ROSA_____ |
| 17 VERDE____ | 45 ROSA_____ | 73 CINZA____ | 101 VERDE____ |
| 18 CINZA____ | 46 VERDE____ | 74 AZUL_____ | 102 CINZA____ |
| 19 VERDE____ | 47 AZUL_____ | 75 ROSA_____ | 103 VERDE____ |
| 20 CINZA____ | 48 CINZA____ | 76 VERDE____ | 104 AZUL_____ |
| 21 ROSA_____ | 49 VERDE____ | 77 AZUL_____ | 105 CINZA____ |
| 22 AZUL_____ | 50 ROSA_____ | 78 VERDE____ | 106 AZUL_____ |
| 23 ROSA_____ | 51 CINZA____ | 79 AZUL_____ | 107 VERDE____ |
| 24 CINZA____ | 52 AZUL_____ | 80 VERDE____ | 108 ROSA_____ |
| 25 ROSA_____ | 53 CINZA____ | 81 ROSA_____ | 109 AZUL_____ |
| 26 CINZA____ | 54 ROSA_____ | 82 VERDE____ | 110 VERDE____ |
| 27 VERDE____ | 55 CINZA____ | 83 CINZA____ | 111 ROSA_____ |
| 28 CINZA____ | 56 VERDE____ | 84 ROSA_____ | 112 AZUL_____ |

| | **M0** | **M1** |
|---|---|---|
| **Tempo** | | |
| **Total de respostas** | | |
| **Incorrretas** | | |
| **Corretas** | | |

**Nomeação de Cor: Folha de Registo**

**Instruções ao participante:** Vamos fazer o mesmo com mais palavras. Queria que me dissesse a **cor da tinta** em que estão impressas as palavras, o mais depressa que puder. Comece no início da 1.ª coluna, quando acabar passe à 2.ª, e assim sucessivamente. Se se enganar, corrija e continue. Como há pouco, só começa depois de eu dar o sinal (dizer "agora"). Entendido? Atenção: Agora!

**Tempo:** Dê o sinal de partida ao mesmo tempo que aciona o cronómetro. O tempo limite é de **120 segundos**.

| | | | |
|---|---|---|---|
| 1 ROSA_____ | 29 AZUL_____ | 57 AZUL_____ | 85 CINZA____ |
| 2 AZUL_____ | 30 CINZA____ | 58 CINZA____ | 86 ROSA_____ |
| 3 VERDE____ | 31 VERDE____ | 59 ROSA_____ | 87 VERDE____ |
| 4 AZUL_____ | 32 ROSA_____ | 60 VERDE____ | 88 AZUL_____ |
| 5 ROSA_____ | 33 AZUL_____ | 61 CINZA____ | 89 CINZA____ |
| 6 CINZA____ | 34 VERDE____ | 62 ROSA_____ | 90 VERDE____ |
| 7 AZUL_____ | 35 AZUL_____ | 63 VERDE____ | 91 ROSA_____ |
| 8 ROSA_____ | 36 VERDE____ | 64 AZUL_____ | 92 CINZA____ |
| 9 CINZA____ | 37 ROSA_____ | 65 VERDE____ | 93 AZUL_____ |
| 10 VERDE____ | 38 CINZA____ | 66 CINZA____ | 94 VERDE____ |
| 11 AZUL_____ | 39 AZUL_____ | 67 AZUL_____ | 95 ROSA_____ |
| 12 ROSA_____ | 40 ROSA_____ | 68 VERDE____ | 96 CINZA____ |
| 13 CINZA____ | 41 AZUL_____ | 69 ROSA_____ | 97 ROSA_____ |
| 14 AZUL_____ | 42 CINZA____ | 70 AZUL_____ | 98 VERDE____ |
| 15 VERDE____ | 43 ROSA_____ | 71 ROSA_____ | 99 ROSA_____ |
| 16 ROSA_____ | 44 CINZA____ | 72 VERDE____ | 100 AZUL_____ |
| 17 CINZA____ | 45 AZUL_____ | 73 AZUL_____ | 101 ROSA_____ |
| 18 VERDE____ | 46 ROSA_____ | 74 CINZA____ | 102 AZUL_____ |
| 19 AZUL_____ | 47 VERDE____ | 75 VERDE____ | 103 CINZA____ |
| 20 ROSA_____ | 48 AZUL_____ | 76 AZUL_____ | 104 VERDE____ |
| 21 CINZA____ | 49 CINZA____ | 77 ROSA_____ | 105 ROSA_____ |
| 22 VERDE____ | 50 VERDE____ | 78 CINZA____ | 106 CINZA____ |
| 23 AZUL_____ | 51 ROSA_____ | 79 VERDE____ | 107 AZUL_____ |
| 24 VERDE____ | 52 CINZA____ | 80 ROSA_____ | 108 CINZA____ |
| 25 CINZA____ | 53 VERDE____ | 81 CINZA____ | 109 ROSA_____ |
| 26 AZUL_____ | 54 CINZA____ | 82 AZUL_____ | 110 AZUL_____ |
| 27 CINZA____ | 55 AZUL_____ | 83 VERDE____ | 111 VERDE____ |
| 28 ROSA_____ | 56 ROSA_____ | 84 AZUL_____ | 112 CINZA____ |

| | **M0** | **M1** |
|---|---|---|
| **Tempo** | | |
| **Total de respostas** | | |
| **Incorretas** | | |
| **Corretas** | | |

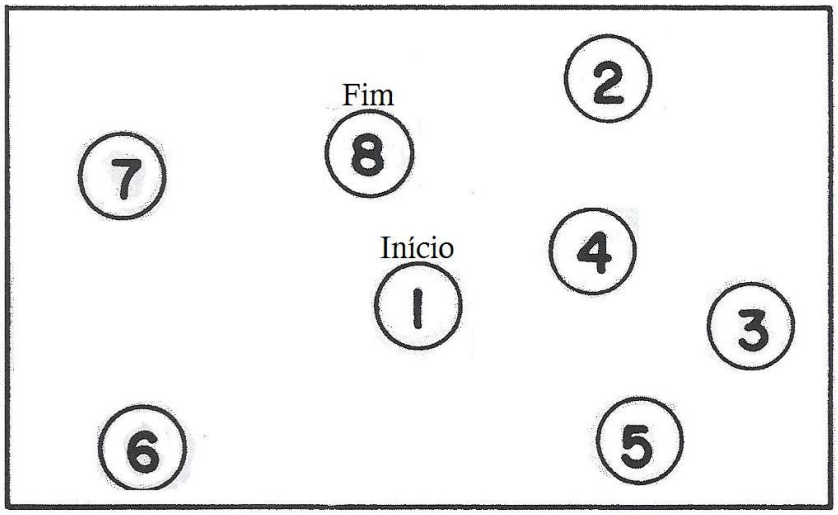
# Folha relativa à Leitura e Nomeação da cor

| | | | |
|---|---|---|---|
| AZUL | VERDE | ROSA | VERDE |
| VERDE | AZUL | VERDE | CINZA |
| ROSA | ROSA | AZUL | ROSA |
| CINZA | AZUL | CINZA | CINZA |
| VERDE | CINZA | ROSA | AZUL |
| AZUL | ROSA | CINZA | CINZA |
| ROSA | VERDE | AZUL | VERDE |
| CINZA | CINZA | CINZA | ROSA |
| ROSA | VERDE | ROSA | VERDE |
| AZUL | AZUL | AZUL | ROSA |
| ROSA | ROSA | ROSA | AZUL |
| CINZA | CINZA | CINZA | VERDE |
| AZUL | VERDE | AZUL | CINZA |
| CINZA | ROSA | VERDE | AZUL |
| ROSA | AZUL | CINZA | VERDE |
| AZUL | VERDE | AZUL | ROSA |
| VERDE | ROSA | CINZA | VERDE |
| CINZA | VERDE | AZUL | CINZA |
| VERDE | AZUL | ROSA | VERDE |
| CINZA | CINZA | VERDE | AZUL |
| ROSA | VERDE | AZUL | CINZA |
| AZUL | ROSA | VERDE | AZUL |
| ROSA | CINZA | AZUL | VERDE |
| CINZA | AZUL | VERDE | ROSA |
| ROSA | CINZA | ROSA | AZUL |
| CINZA | ROSA | VERDE | VERDE |
| VERDE | CINZA | CINZA | ROSA |
| CINZA | VERDE | ROSA | AZUL |

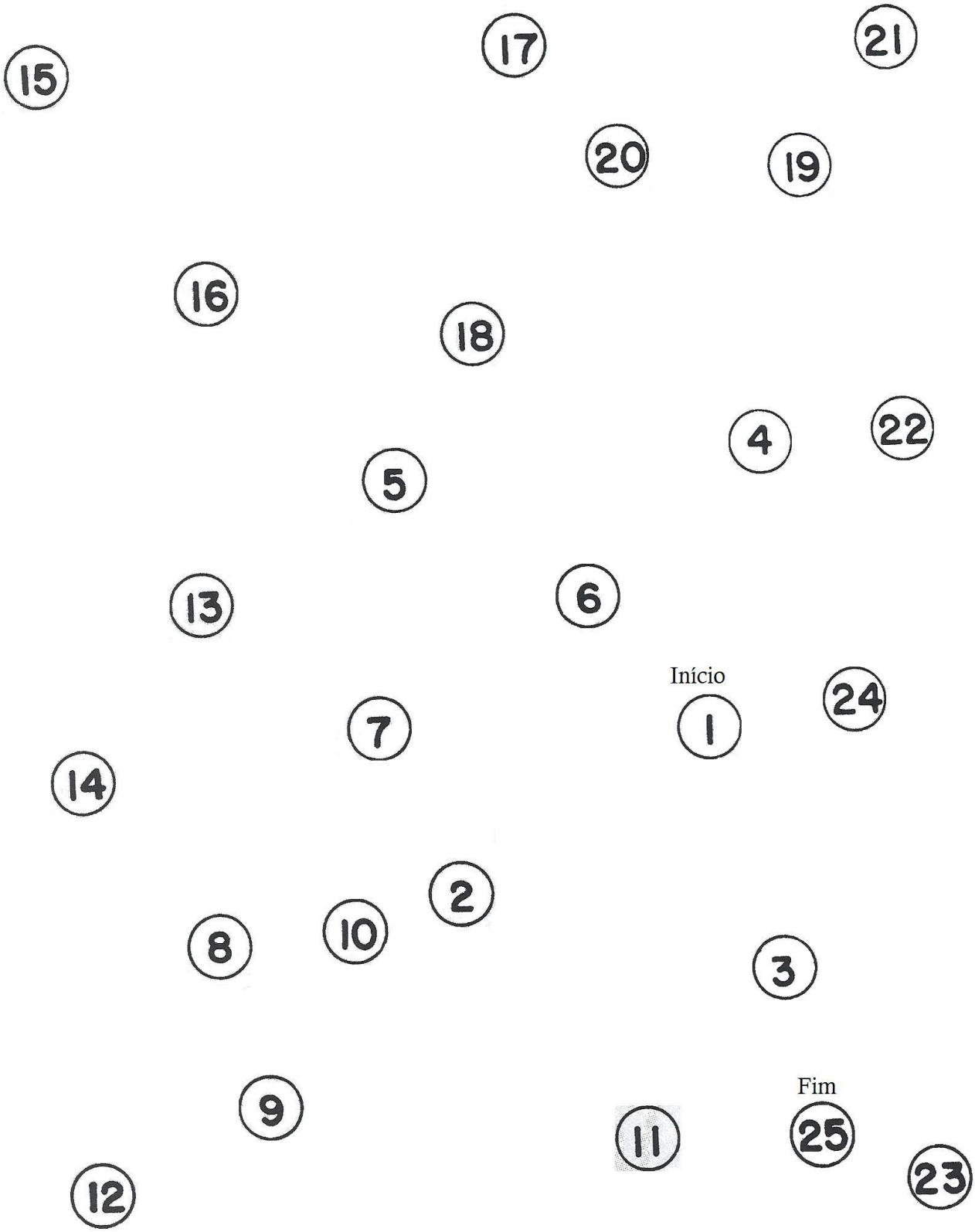
**Annex 5 –** Trail making test part A and B (Portuguese version)

# Trail Making Test - Sample

## Parte A

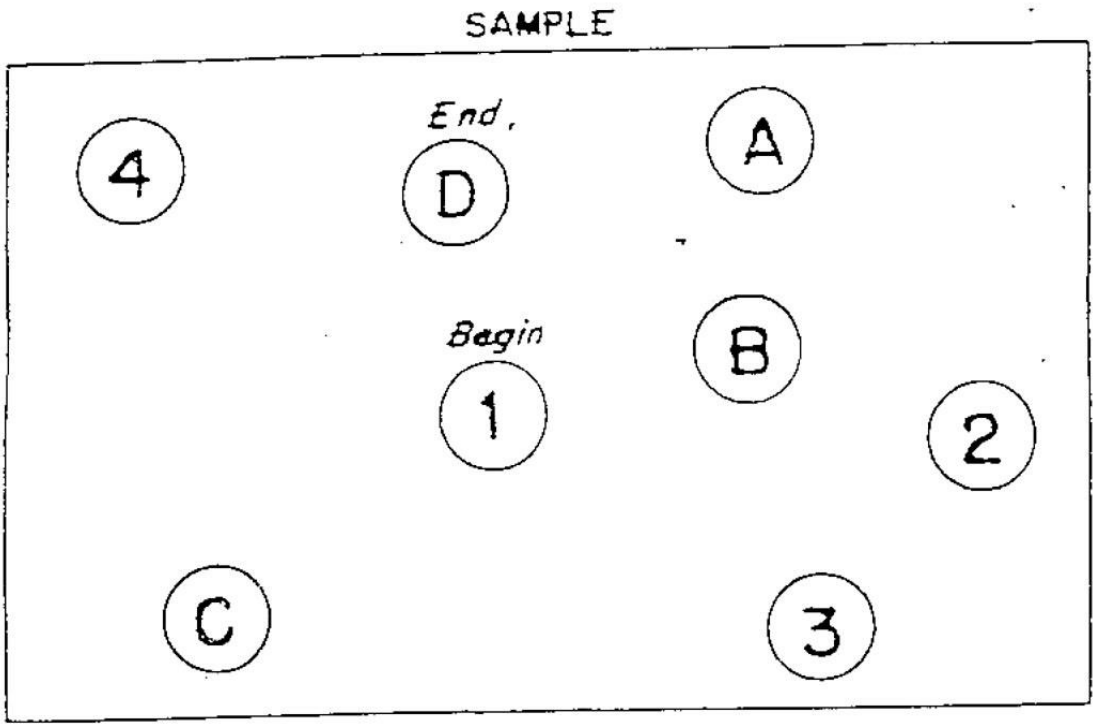


# Parte A

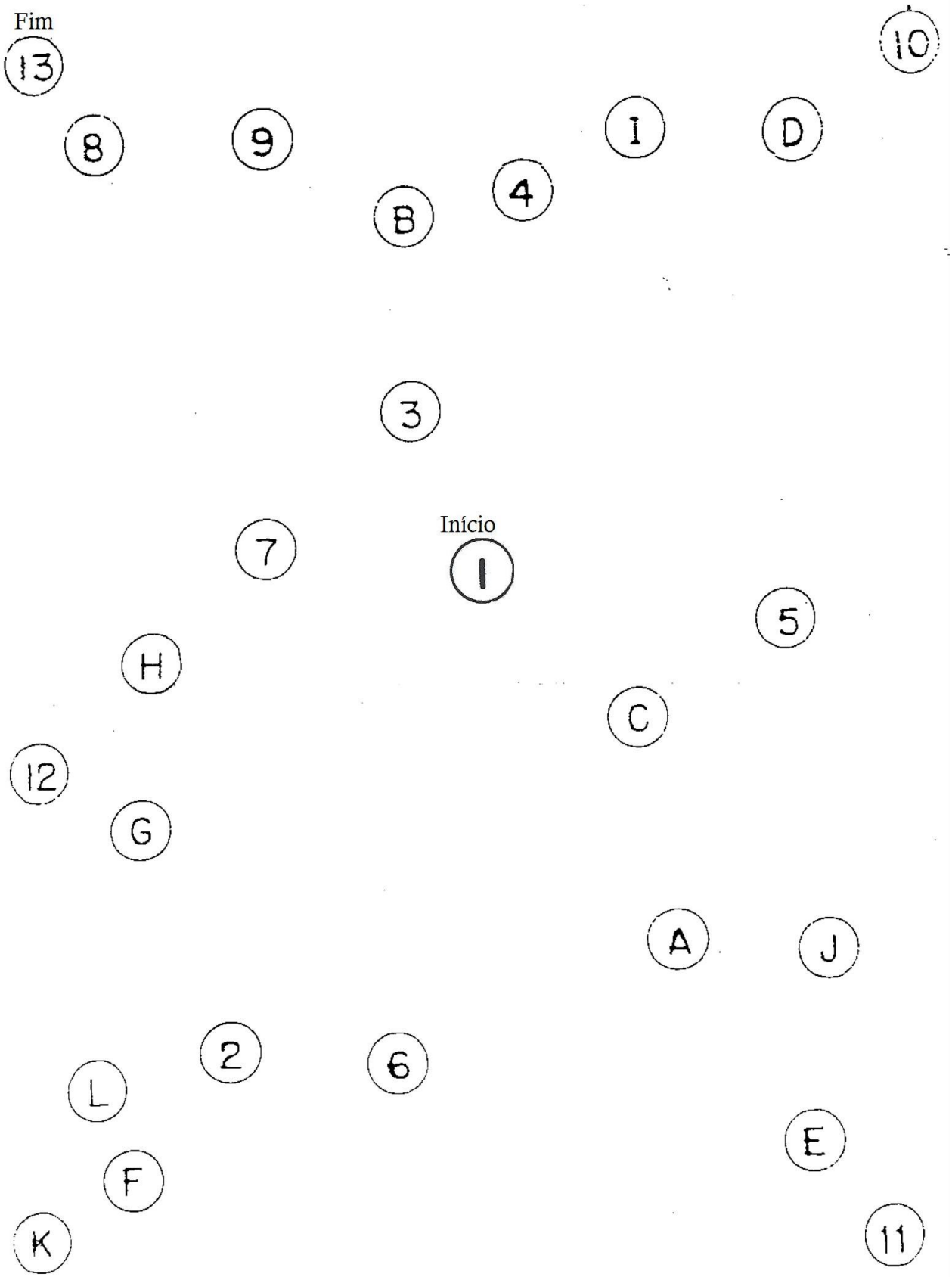

15
17
21
20
19
16
18
4
22
5
13
6
Início
24
1
7
14
2
8
10
3
Fim
9
11
25
23
12

# Trail Making Test - Sample

## Parte B



# Parte B




| Tempos | M0 | M1 |
|---|---|---|
| Trail B | | |

**Annex 6 –** Verbal digital test (Forward way and backward way) Portuguese version

| | Dígitos em Sentido Direto | | | | | Dígitos em Sentido Inverso | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ens.1 | 1 - 7 | | | | Ens.1 | 2 - 4 | | | |
| | Ens.2 | 6 - 3 | | | | Ens.2 | 5 - 7 | | | |
| Item 2 | Ens.1 | 5 - 8 - 2 | | | Item 2 | Ens.1 | 6 - 2 - 9 | | | |
| | Ens.2 | 6 - 9 - 4 | | | | Ens.2 | 4 - 1 - 5 | | | |
| Item 3 | Ens.1 | 6 - 4 - 3 - 9 | | | Item 3 | Ens.1 | 3 - 2 - 7 - 9 | | | |
| | Ens.2 | 7 - 2 - 8 - 6 | | | | Ens.2 | 4 - 9 - 6 - 8 | | | |
| Item 4 | Ens.1 | 4 - 2 - 7 - 3 - 1 | | | Item 4 | Ens.1 | 1 - 5 - 2 - 8 - 6 | | | |
| | Ens.2 | 7 - 5 - 8 - 3 - 6 | | | | Ens.2 | 6 - 1 - 8 - 4 - 3 | | | |
| Item 5 | Ens.1 | 6 - 1 - 9 - 4 - 7 - 3 | | | Item 5 | Ens.1 | 5 - 3 - 9 - 4 - 1 - 8 | | | |
| | Ens.2 | 3 - 9 - 2 - 4 - 8 - 7 | | | | Ens.2 | 7 - 2 - 4 - 8 - 5 - 6 | | | |
| Item 6 | Ens.1 | 5 - 9 - 1 - 7 - 4 - 2 - 8 | | | Item 6 | Ens.1 | 8 - 1 - 2 - 9 - 3 - 6 - 5 | | | |
| | Ens.2 | 4 - 1 - 7 - 9 - 3 - 8 - 6 | | | | Ens.2 | 4 - 7 - 3 - 9 - 1 - 2 - 8 | | | |
| Item 7 | Ens.1 | 5 - 8 - 1 - 9 - 2 - 6 - 4 - 7 | | | Item 7 | Ens.1 | 9 - 4 - 3 - 7 - 6 - 2 - 5 - 8 | | | |
| | Ens.2 | 3 - 8 - 2 - 9 - 5 - 1 - 7 - 4 | | | | Ens.2 | 7 - 2 - 8 - 1 - 9 - 6 - 6 - 3 | | | |
| Item 8 | Ens.1 | 2 - 7 - 5 - 8 - 6 - 2 - 5 - 8 - 4 | | | **Total Dígitos em Sentido Inverso** (Máximo = 14) | | | | | |
| | Ens.2 | 7 - 1 - 3 - 9 - 4 - 2 - 5 - 6 - 8 | | | | | | | | |
| **Total Dígitos em Sentido Direto** (Máximo = 16) | | | | | **Pontuação Total Obtida** Sentido Direto + Sentido Inverso (Máximo = 30) | | | | | |

## Annex 7 – Cognitive Exercises (CD)

**Annex 8 -** Cognitive Exercise Program

| Sessions | Executive Functions and Number of Exercises (X) | Progression | Week |
|---|---|---|---|
| 1st | Cognitive flexibility (1) and selective attention (2) | | 1 |
| 2nd | Cognitive flexibility (1) and selective attention (2) | Same exercises of session 1(numbers, their order and the colors of the exercises were altered). | 2 |
| 3rd | Cognitive flexibility (1) and selective attention (2) | | 3 |
| 4th | Cognitive flexibility (1) and selective attention (2) | Only 1 new exercise was implemented. However, the progression was augmented, on the same manner explained before. | 4 |
| 5th | Selective attention (1), selective attention (1) and sequencing and planning (1) | 1 new exercises were implemented | 5 |
| 6th | Selective attention (1), cognitive flexibility (1) and sequencing and planning (1) | 2 of the exercises were kept, but a new one was added already used before | 6 |
| 7th | Cognitive flexibility (2) and sequencing and planning (1) | Re-introduced 2 of the exercises already used, however one exercise was maintained (swapping the order of their execution | 7 |
| 8th | Cognitive flexibility (2) and sequencing (1) | For 2 exercises we changed the sentences and added a new one | 8 |
| 9th | Cognitive flexibility (1), sequencing (1) and working memory (1) | We used 1 exercise from the previous session (changing all the sentences and numbers) and implemented a new exercise | 9 |
| 10th | Cognitive flexibility (1), sequencing (1) working memory and problems resolutions (1) | We used 2 exercises from the previous session (changing all the sentences and numbers, also adding more numbers) | 10 |
| 11th | Cognitive flexibility (1), sequencing (1) and working memory and problems resolution (1) | All 3 exercises from the previous session were used (modifying all shapes, colors, sentences, numbers, and increasing the digits amount) | 11 |
| 12th | Cognitive flexibility (1), sequencing (1) and working memory and problems resolution (1) | We kept 2 of the previous exercises (changing shapes and colors and the digits went from dozens to hundreds. A new exercise was added (already used before, but doing a progression with the time altered) | 12 |
| 13th | Cognitive flexibility (1), sequencing (1), selective attention and problems resolution (1) | We kept 2 of the exercises (changing shapes and colors and the digits went from dozens to hundreds). An exercise used before was added | 13 |
| 14th | Selective attention and problems resolution (1) and cognitive flexibility (2) | We kept one of the previous exercises, but we altered the colors and pictures' order. Two exercises were added, already used before | 14 |
| 15th | Selective attention and problems resolution (2) and cognitive flexibility (1) | We kept 2 of the previous exercises , performing the required changes for the existence of progression. Also a new exercise for divided attention was implemented. | 15 |
| 16th | Selective attention and problems resolution (2) and cognitive flexibility (1) | We used 2 exercises from the previous session, performing the required changes for the existence of progression. Also a new exercise was implemented. | 16 |
| 17th | Working memory (1), sequencing and working memory (1) and cognitive flexibility (1) | We implemented a new exercise, but used 2 of the exercises from the previous session, altering all its sentences and images. | 17 |
| 18th | Working memory (1), sequencing and working memory (1) and cognitive flexibility (1) | We kept 2 exercises from the session before, performing the required changes for the existence of progression. Also a new exercise was implemented. | 18 |
| 19th | Problems resolution and working memory (1) and cognitive flexibility and problems resolution (2) | We implemented 3 exercises, used before, changing all that was required, namely altering all sentences, time orders, colors and shapes. | 19 |
| 20th | Working memory (1), working memory and problems resolution (1) and cognitive flexibility and problems resolution (1) | We implemented 2 new exercises (working memory and problems resolution) and kept an exercise from the previous session, focused on cognitive flexibility and problems resolution. | 20 |
| 21st | Selective attention and working memory (1) and cognitive flexibility (1) | We kept an exercise from the previous one. Afterwards we added 2 exercises already used before. | 21 |
| 22nd | sequencing and working memory (1), cognitive flexibility (1) and sequening and planning (1) | We implemented 3 exercises, previously used, performing the appropriate changes, namely the alteration of all the phases of daily tasks, times orders, colors and shapes. | 22 |